FINAL REPORT

NOAA International Coral Reef Conservation Program

Grant No. NA03NOS4630223: "Testing indicators of MPA management effectiveness in Kosrae, FSM."

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Introduction

The management of coral reef ecosystems and fisheries is a complex and difficult task (Botsford et al. 1997; Costanza et al. 1998). In many developing Pacific Island nations, nearshore ecosystems are under heavy pressure from rapidly increasing anthropogenic stress. In most cases, the problem is exacerbated by a lack of management capacity within government resource management agencies (Rudd et al. 2003). Marine Protected Areas (MPAs) have received much attention in recent years as a viable approach to resource management in developing island nations (Roberts et al. 2001). The primary goals of MPAs are to protect critical habitat and biodiversity, and to sustain or enhance fisheries by preventing spawning stock collapse and providing recruitment to fished areas (Halpern 2003, Abesamis et al. 2006; Goni et al. 2006). Many Pacific Island cultures practice marine tenure systems whereby coral reefs and other marine resources are under family or community ownership. Community-managed or co-managed MPAs fit particularly well with such cultural practices, as resource users are more likely to feel stewardship for resources that they actually own. For these reasons, MPAs have become a major component of Pacific Island coral reef conservation strategies.

The island of Kosrae in the Federated States of Micronesia is among the least developed of the U.S. Territories and Freely Associated States. Approximately 7700 people live on Kosrae, which is 42 square miles in area. Many Kosraeans are reliant on the ocean for their livelihood. The island is surrounding by coastal mangrove forest and extensive fringing reefs. Kosrae's reefs and mangroves are considered some of the healthiest in Micronesia and support a small but growing diving and ecotourism industry (currently about 1000 visitors per year). However, recent coastal development and upland land use patterns have resulted in coastal erosion and degradation of the coastal mangrove ecosystem, placing the health of Kosrae's reefs at risk. Unfortunately, the Kosraean government does not possess extensive finances, manpower, or technical expertise. Thus, it is important that both institutional and community capacity be strengthened and integrated to ensure sound management of Kosrae's coastal resources. Over the past several years, Kosrae has begun to develop an MPA program that involves co-management of coastal resources by local communities working in concert with state resource management agencies.

Despite the many potential benefits of MPAs to coastal management programs (see Halpern 2003), the majority of MPAs do not meet their management objectives, or have no clearly defined management objectives (McClanahan et al. 2006). In a joint initiative aimed improving the management of MPAs, the World Conservation Union's (IUCN) World Commission on Protected Areas (WCPA) and the World Wide Fund for Nature (WWF), in collaboration with international experts, developed a set of 44 MPA effectiveness indicators. These indicators are grouped into three broad categories: biophysical, socioeconomic and governance. The purpose of each individual indicator is to determine or predict the success of a specific aspect of MPA management. Combining a set of indicators from each of the categories will enable managers to determine or predict which aspects of a management plan are sound and which need improvement. In order to improve the management of Kosrae's MPAs, we propose to develop, refine and test indicators of MPA effectiveness in conjunction with a larger international effort. The objective of this study is to assess the management effectiveness of two pilot MPA sites by measuring a suite of biophysical, socioeconomic and governance variables ('indicators') appropriate to the local conditions that influence the performance of Kosrae's MPAs. These indicators were developed by the in a joint initiative aimed at improving the management of MPAs (Ehler et al. 2002).

This project focuses on the two largest MPAs in Kosrae, the Utwe-Walung Marine Park and the Trochus Sanctuary. Two control areas were designated in unmanaged areas adjacent to the MPAs. Selection of indicators occurred in March 2003, during meetings with the project investigators and Kosraean resource managers, technical staff, and the Utwe-Walung Marine Park Board of Directors. The Board of Directors chose the final list of indicators for the Marine Park, based on relevance to Kosrae, feasibility, and urgency. The final list of indicators for the Trochus Sanctuary was selected by managers from Kosraean resource management agencies (KIRMP, DALF/DMR). These lists were designed to be flexible and adaptive, so that some indicators might be added or replaced as need dictated. For example, we had originally proposed to analyze catch per unit effort (CPUE) data from the DALF/DMR as one of the biophysical indicators, but the data were not robust enough to show any trends, so CPUE was dropped as an indicator.

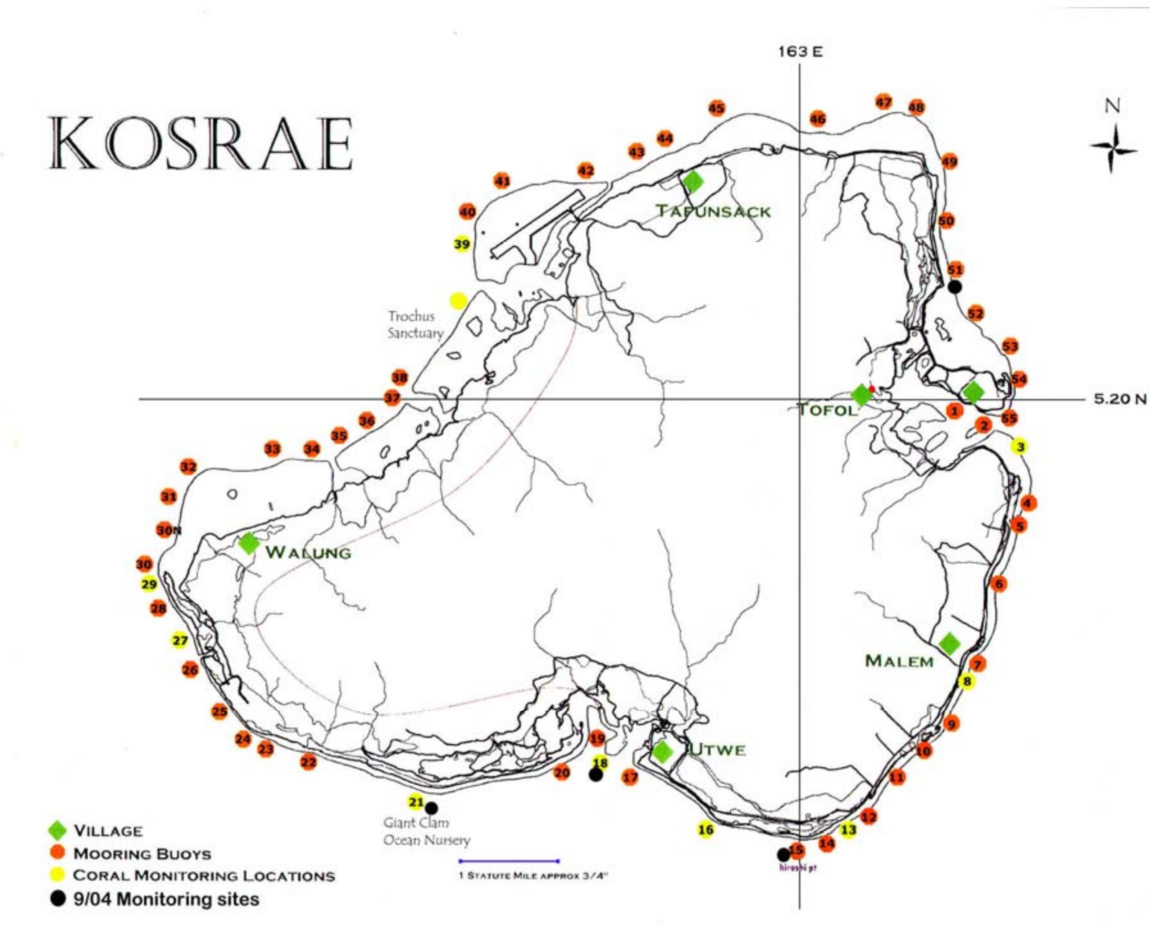

Figure 1. Kosrae MPA and control monitoring sites. Yellow symbols indicate sites in and adjacent to MPAs. Black symbols indicate sites visited in September 2004. Study sites include buoys 15 (Hiroshi Point), 18 (Utwe Bay), 21 (Giant Clam Ocean Nursery) and 51 (Pikusrik), and the Trochus Sanctuary.

Testing of Biophysical Indicators

There are numerous physical and biological aspects of MPAs that can indicate whether or not they are reaching, or are likely to reach, their management objectives. One of the greatest obstacles to management of Kosrae's marine resources is a lack of information on the distribution and abundance of marine fish and invertebrates, and of the general biology of many key species. In order to develop meaningful management regulations for MPAs or fished areas, more information is needed on population abundance, population size/age/sex structure, and essential habitats for spawning and recruitment. This project will integrate efforts from Kosrae resource management agencies and academic researchers monitoring MPAs.

1. *Focal Species Abundance*:

Project staff assessed the population density and biomass of 3 key fish families: surgeonfishes (Acanthuridae), parrotfishes (Scaridae), rabbitfishes (Siganidae), and 5 large, mobile reef fishes: humphead wrasse (*Cheilinus undulatus*), bumphead parrotfish (*Bolbometopon muricatum*), and 3 groupers (camouflage grouper *Epinephelus polyphekadion*, brown-marbled grouper *Epinephelus fuscoguttatus*, squaretailed coralgrouper *Plectropomus areolatus*, leopard coralgrouper Plectropomus leopardus, and giant coralgrouper Plectropomus laevis). We also assessed 2 key invertebrates: trochus (*Trochus nilotica*) and giant clam (*Tridacna spp.*). We had had originally planned to assess soldierfishes (genus *Myripristes*) also, but their nocturnal habits made them too difficult to assess during daytime dives.

Density of reef fish was estimated by divers using standard underwater visual census (UVC) methods. Two sites were chosen within each of the two MPAs and two control areas. At each site, four replicate 4 x 25 m^2 transects were laid along the fore-reef slope at a depth of approximately 15 m. Divers swam along the transect, counting all individuals of the focal species and estimating their length to the nearest cm (see Focal Species Population Structure below). In addition to transects, abundance of groupers, bumphead parrotfish, and humphead wrasse were estimated using long-swim timed UVC. In two or more 15-minute increments per site, fishes were counted within 10m either side of an imaginary line in front of the diver as he/she swims at a constant rate along a fixed depth interval. If there was a habitat limitation, such as a wall or steep slope along one side of a transect, the width of the transect is adjusted accordingly (e.g., 10 m on the left and 2 m on the right, etc.). Start/stop points were marked with small surface buoys and the distance traveled determined by GPS fixes at those points. The area surveyed was then calculated from these measurements. This method is more appropriate than standard line transects or point counts for counting large, mobile fishes (T.J. Donaldson, University of Guam Marine Laboratory, unpublished data; J.H. Choat, James Cook University, personal communication).

As per our original project timeline, these surveys were conducted weekly in January of 2004 (i.e. 4 times in total). We completed 16 dives over the two MPAs and 2 control sites and found no statistically significant differences in density of any focal species between MPAs and adjacent control areas (Table 1). An interesting (and alarming) fact was that no large groupers (e.g. *Epinephelus polyphekadion, E. fuscoguttatus, Plectropomus leopardus, P.*

areolatus, and *P. laevis*) were observed on any census. Moreover, none of these species were observed during 75 census dives for another NOAA-funded research project.

Species	Utwe-Walung Marine Park	Haroshi Point	Trochus Sanctuary	Yelu	ANOVA results
A. lineatus	1.4 ± 1.1	1.1 ± 0.7	0.9 ± 0.8	1.2 ± 0.9	n.s.
L. kasmira	0.3 ± 0.5	0.2 ± 0.3	0.4 ± 0.6	0.3 ± 0.3	n.s.
C. undulatus	0.1 ± 0.3	0	0	0.2 ± 0.4	n.s.
B. muricatum	0	0.1 ± 0.3	0	0.1 ± 0.3	n.s.
Epinephelus sp.	0	0	0	0	n.s.
Plectropomus sp.	0	0	0	0	n.s.
Rabbitfishes	2.3 ± 1.4	2.0 ± 0.7	1.8 ± 1.0	2.3 ± 0.8	n.s.
Rudderfishes	1.6 ± 2.0	1.0 ± 1.1	1.7 ± 0.9	1.3 ± 1.5	n.s.

Table 1. Density of focal reef fish species per 100 m^2 at 4 sites in Kosrae, FSM in 2004 Density of *Cheilinus undulatus* and *Bolbometopon muricatum* was estimated from long-swim timed underwater visual census (see above).

Density of giant clam and trochus were estimated in a similar manner in September 2004 at 6 sites (Hiroshi Point, Utwe Bay, Giant Clam Nursery (Buoy 21), Trochus Sanctuary, Yela, and Pikusrik). We were unable to estimate biomass for these invertebrates. Since giant clams are sessile and do not undergo seasonal migrations, and trochus move over a very limited range, we decided that there was no need to repeat the census for these species twice in one year. Density of trochus varied greatly between sites (ANOVA, $F = 17.9$, $p < 0.001$) but was not higher in protected areas than in adjacent fished areas (Figure 3). The density of trochus in Utwe Bay and at nearby Hiroshi Point was very low. The density of Trochus was higher near the Giant Clam Nursery (within the Marine Park). Much higher densities occurred on the northwest and northeast reefs, with the highest densities occurring at Pikusrik, in the northeast. Density of trochus did not differ between the Trochus Sanctuary and nearby Yela. Density of giant clams was uniformly low at all sites (Figure 3), except for Hiroshi Point, which had significantly higher densities of *T. squamosa*. The largest species of clam, *T. gigas*, was found only at the Giant Clam Nursery (Buoy 21) and only at very low densities.

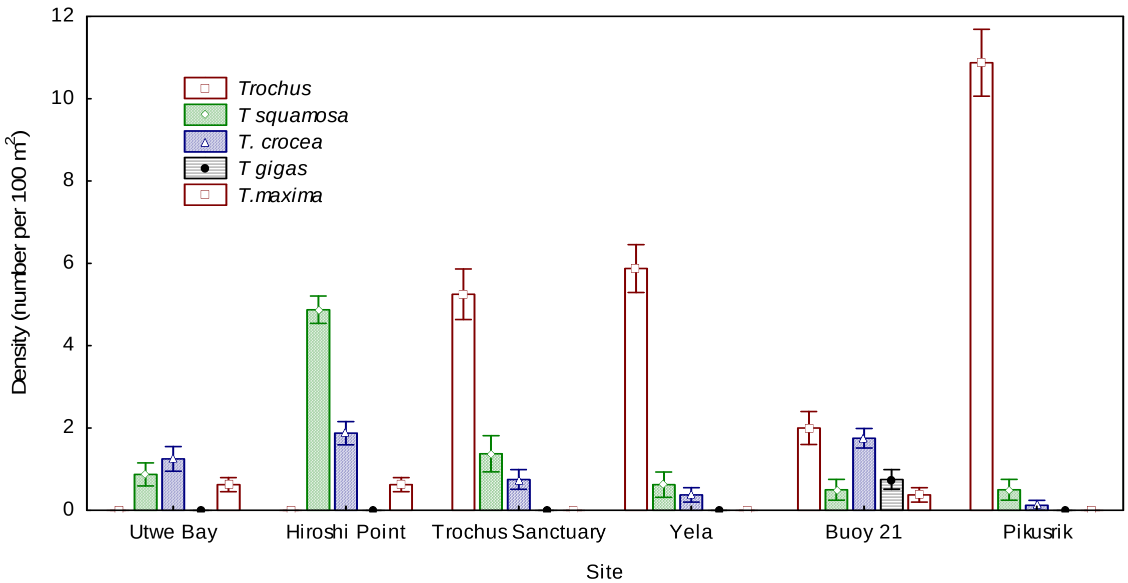

Figure 2. Density of Trochus and giant clams (*Tridacna* spp.) at 6 study sites in Kosrae, FSM in 2005. Utwe Bay and Buoy 21 are both within the Utwe-Walang Marine Park.

Focal species biomass: Further surveys were undertaken in 2005 to estimate biomass of reef fish in MPAs and control sites. Biomass was estimated for 3 fish families (Scaridae, Acanthuridae and Siganidae) by substituting the length of each fish on the transects into published length-weight regressions for that species (FishBase, www.fishbase.org). The total weight of all fish by species was then used as an estimate of biomass. These biomass estimates were conducted at the same 6 sites listed for invertebrate density above. There was no significant difference among sites in biomass of parrotfish (ANOVA, F = 2.6, p = 0.57), surgeonfish (ANOVA, F = 4.1, p = 0.16) or rabbitfish (ANOVA, F = 2.3, p = 0.48).

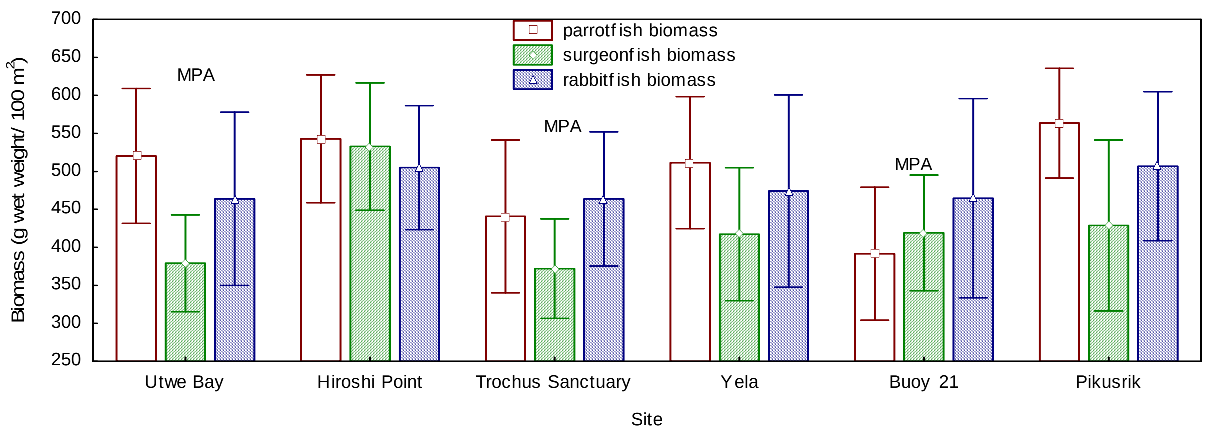

Figure 3. Biomass of reef fish at 6 study sites in Kosrae, FSM in 2005. Utwe Bay and Buoy 21 are both within the Utwe-Walang Marine Park.

Conclusion: Implementation of the Utwe-Walung Marine Park and Trochus Sanctuary appeared to have no effect on focal species abundance or biomass.

2. *Focal Species Population Structure*

The viability of a species can be measured in terms of its size/age structure, growth rate, and mortality rate. Size structure is particularly important as it determines the reproductive output of the population. In fish, fecundity increases exponentially with length, so having abundant large fish in a protected area will greatly increase the number of eggs and larvae produced.

Size (total length) of focal reef fish species was estimated visually in 2004 at 4 sites. There were no significant differences in total length of any reef fish species between the MPAs and control areas (Table 2). Trochus and giant clams occurring on the transects were measured *in situ* to the nearest mm with a ruler.

Species	Utwe-Walung Marine Park	Haroshi Point	Trochus Sanctuary	Yela	ANOVA results
A. lineatus	16 ± 3.1	13 ± 2.7	15 ± 3.8	14 ± 2.9	n.s.
L. kasmira	13 ± 3.5	12 ± 3.3	14 ± 2.6	14 ± 3.3	n.s.
C. undulatus	32 ± 6.3	0	0	28 ± 7.6	n.s.
B. muricatum	0	22 ± 3.3	0	21 ± 3.4	n.s.
Epinephelus sp.	0	0	0	0	n.s.
Plectropomus sp.	0	0	0	0	n.s.
Rabbitfishes	15 ± 4.1	16 ± 3.8	16 ± 3.1	14 ± 3.7	n.s.
Rudderfishes	18 ± 2.0	20 ± 3.1	19 ± 2.9	18 ± 5.1	n.s.

Table 2. Estimated total length (cm) of reef fishes at 4 sites in Kosrae, FSM in 2004.

Length frequency analysis was also performed on the 2005 fish survey data at all 6 sites. For all 3 families (parrotfish, surgeonfish and rabbitfish), length frequency histograms revealed little variation between sites. Rather than reproduce 18 length frequency histograms here, we present among-site variation in mean length of each fish family in Figure 4. There was no apparent affect of MPA implementation on size of fish. Mean length of parrotfishes was highest at Pikusrik and lowest at Buoy 21 inside Utwe-Walang Marine Park (ANOVA, $F = 12.3$, $p < 0.05$). In contrast, mean length of surgeonfish was highest at both Pikusrik and Buoy 21 in the Marine Park, but lowest at Utwe Bay, also in the Marine Park (ANOVA, $F = 9.9$, $p < 0.05$). Mean length of rabbitfish was highest at Yela and lowest at Buoy 21 and Hiroshi Point (ANOVA, $F = 7.6$, $p < 0.05$).

Conclusion: There was no variation in reef fish population structure attributable to implementation of the MPAs.

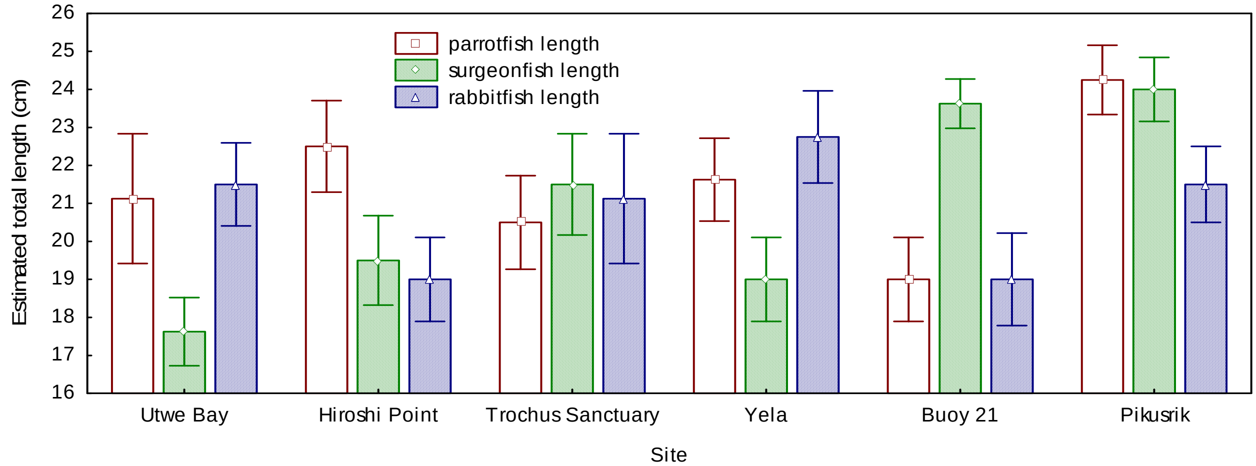

Figure 4. Mean estimated length of reef fish at 6 sites in Kosrae, FSM in 2005. Utwe Bay and Buoy 21 are both inside Utwe-Walung Marine Park.

3. *Habitat Distribution and Complexity*:

Four reefs within the Kosrae reef system were surveyed from September 28 to October 2, 2004. Due to logistical constraints, we were unable to conduct benthic habitat surveys at the Trochus Sanctuary and Yela sites. Each reef was surveyed using replicate (n=4) 25m x 2m belt transects at two depths (6-8m and 15-18m). Along each transect, the following data were obtained: benthic composition (percent live hard coral cover, rock/crustose coralline algae, rubble, dead standing coral, sand/silt, macroalgae, soft coral, sponges), topographic complexity. Data on benthic composition are being processed and will be presented in the next progress report. Topographic complexity was obtained by lowering a weighted chain to follow the benthic contours immediately underneath the straightened transect line. This provides a measure of coral/rock height and irregularity relative to a flat surface. Complexity was then calculated as:

$$\frac{\text{Length of weighted chain}}{\text{Length of transect line}}$$

Table 2 provides a brief description of each of the sites visited, as indicated on Figure 1. Reefs were generally in good condition, with little sign of human impact. The exception to this was the deeper zone of the Utwe Bay reef; these transects contained a noticeable amount of black silt, which covered many of the large coral heads and was probably responsible for the extensive partial mortality observed on many coral colonies. The black color of the silt denotes a terrigenous origin, and the river emptying into the bay was undoubtedly the main source. Both the Pikusrik and Giant Clam Nursery reefs contained a greater amount of dead standing coral than the other sites, and the degree of weathering and cover by filamentous algae suggested that a mortality event may have occurred within the last 2-4 years. Several Crown-of-Thorns starfish *(Acanthaster planci)* were observed at the Pikusrik site, which is dominated by tabular acroporids; a preferred food item of this starfish. The pattern of high mortality within this reef—a narrow band, 10-20m wide in the shallow zone, suggested that predation by the starfish was the probable cause of mortality. Tabular acroporids on either side of this band—both shallow and deeper—were healthy, which does not suggest bleaching as a probable cause. At the Giant Clam site, a large amount of dead standing coral of a variety of species scattered throughout the shallow nearshore zone suggested a possible bleaching event within the recent past. However, recovery appears to be ongoing; a large number of juvenile colonies, 2-8 cm in diameter had recruited onto these dead standing colonies.

Table 2. Site descriptions of reefs surveyed during the September 2004 baseline assessment. N=4 transects at each of two depths (6-8 m and 16-18 m).

Site	**Site Description**
Hiroshi Point (Buoy 15)	High relief in both deep and shallow portions of reef; large coral bommies; reef in good condition; high live coral cover; steep slope
Utwe Bay (Buoy 18)	Within MPA, near east border; offshore of river mouth; low relief; with noticeable black silt in deeper transects and dead coral; steep slope with medium to high relief in shallows
Giant Clam Nursery (Buoy 21)	Within MPA, near western border; nearshore steep slope with high relief in both shallow and deep zones; fair amount of rubble and dead coral, suggesting mortality 2-4 years ago, but high recruitment, with obvious signs of recovery
Trochus Sanctuary	Within MPA, near center, wide reef shelf with moderate slope and high relief, more rubble and dead coral than other sites
Yela	Near to airport runway; moderate slope and relief, abundant dead coral but also signs of recovery
Pikusrik	Gentle slope offshore of river mouth to short wall at 20m; dominance by *Acropora* tables in shallows, but high mortality (probably either *Acanthaster planci* or bleaching) in a strip (30-50m wide) at mid-depth. Low relief, with abundant pavement in shallow zone; higher relief with more boulders in deeper transects

Substrate composition at the four study sites is shown in Figures 5 and 6. Live hard coral cover did not differ between sites (MANOVA, $p = 0.62$) and represented about 40-50% of the benthic cover on shallow reefs and 50-60% on deep reefs. Live coral was the most common substrate at all 4 sites, followed by rock with turf algae and crustose coralline algae (CCA). The only exception was the shallow reef at the Giant Clam Nursery (Buoy 21), where rock with turf algae and CCA covered slightly more area than live hard coral. Dead standing coral was significantly higher at Pikusrik than the other sites (MANOVA, $p < 0.05$). Although we were unable to perform line intercept transects at the Trochus Sanctuary and Yela sites, dive observations indicated an estimated live hard coral cover of approximately 18% at the Trochus Sanctuary and 25% at Yela. These values are less than half the coverage of the other sites, indicating that some serious damage has occurred on the northwest reefs, probably as a result of the airport and runway construction.

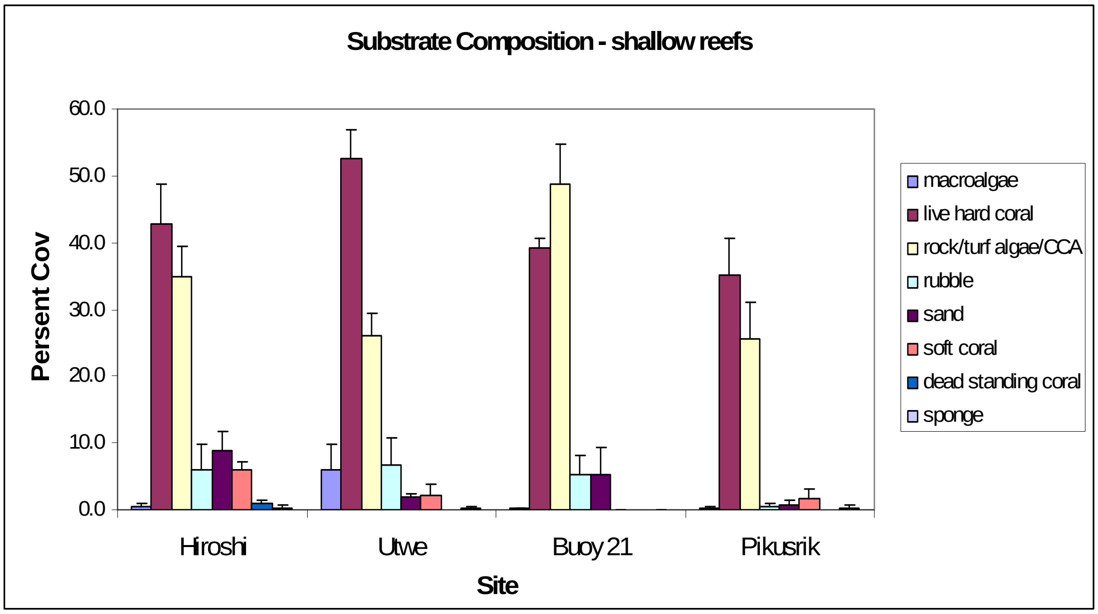

Figure 5. Percent cover of substrate types at 6-8 m depth at 4 sites in Kosrae. CCA = crustose coralline algae.

Conclusion: Habitat distribution and complexity varied little by geographic location among sites, whether MPA or control site. Reefs were generally very healthy with high live coral cover. Reefs near the airport had much lower live coral cover, probably as a result of runway construction.

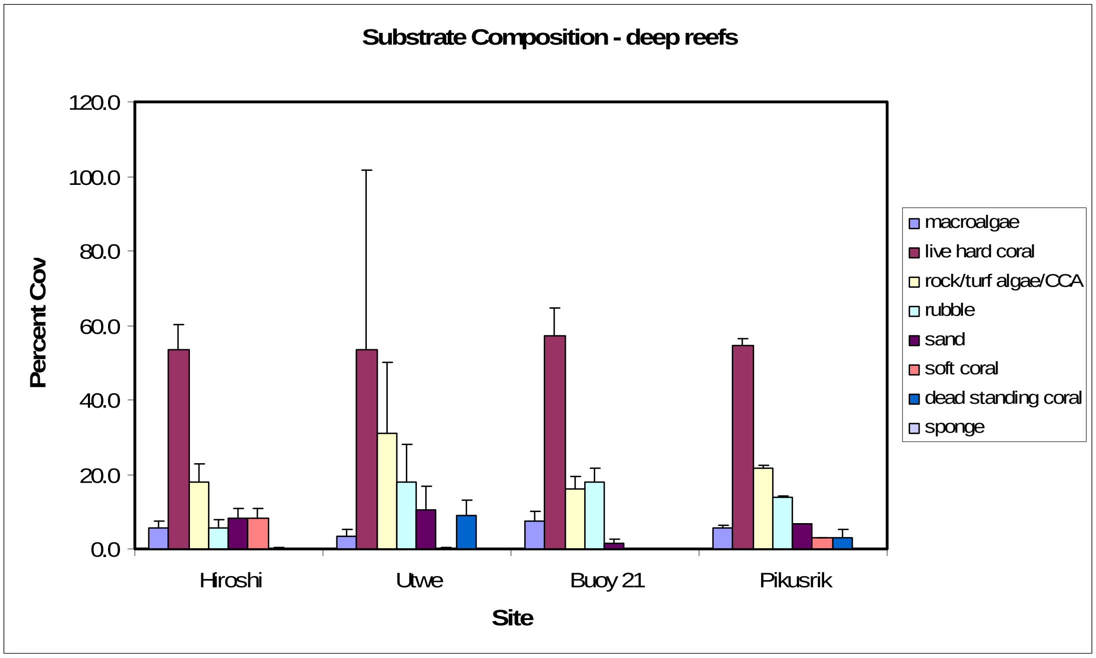

Figure 6. Percent cover of substrate types at 16-18 m depth at 4 sites in Kosrae. CCA = crustose coralline algae.

Topographic complexity (Figure 6) did not differ significantly between sites on either shallow (6-8 m) or deep (16-18 m) transects.

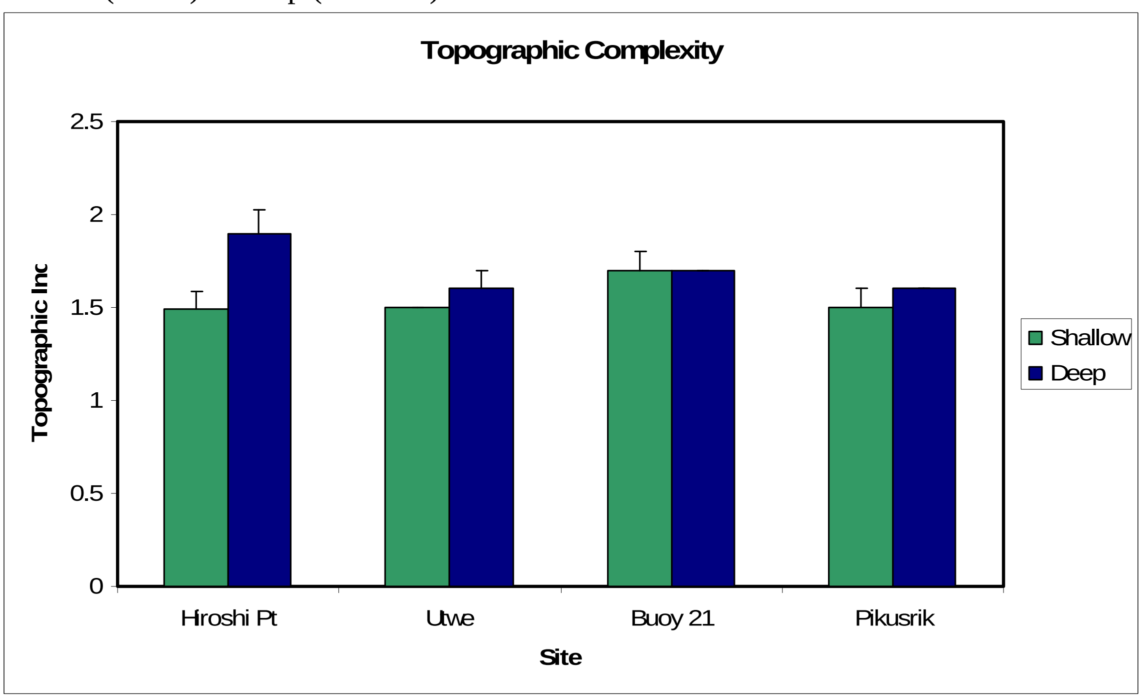

Figure 5. Topographic complexity of substrate at 4 sites in Kosrae. Shallow = 6-8 m, deep = 16-18 m.

4. *Water Quality*:

Kosrae does not have a water quality monitoring program at present due to lack of appropriate monitoring equipment. The Utwe-Walung Marine Park contains some of the world's oldest mangrove forests, which buffer the fringing reefs from sedimentation by filtering runoff. Elsewhere on Kosrae, many mangrove areas have been cleared for roads and coastal development projects. In these areas, Kosrae's heavy rains (240 inches per year) carry large sediment loads directly onto the fringing reef.

Water quality testing was carried out at each site, and included the following variables:

Temperature
Salinity
Dissolved oxygen
Turbidity

Temperature, salinity and dissolved oxygen were measured in August-September 2004 and August-September 2005 with a YSI 85 handheld probe. August-September was chosen as it is likely the time of thermal maxima which could lead to coral bleaching. We were unable to procure a turbidity meter and thus used a Secchi disk to determine horizontal visibility as a proxy of water clarity. All readings were taken between 12 pm and 4 pm on a high tide.

Temperature did not vary between years at any site (2-way ANOVA, $F = 2.8$, $p = 0.63$). Temperature means were thus pooled and compared between sites. Summer water temperatures at each site are shown in Figure 7. Surface temperatures appeared to be somewhat cooler at the southeast corner of Kosrae (Hiroshi Point and Utwe Bay), but the difference was not statistically significant (2-way ANOVA, $F = 3.5$, $p = 0.21$). Temperature at 10 m depth appeared to be lowest at the Trochus Sanctuary, but again the difference was not statistically significant (2-way ANOVA, $F = 3.8$, $p = 0.19$).

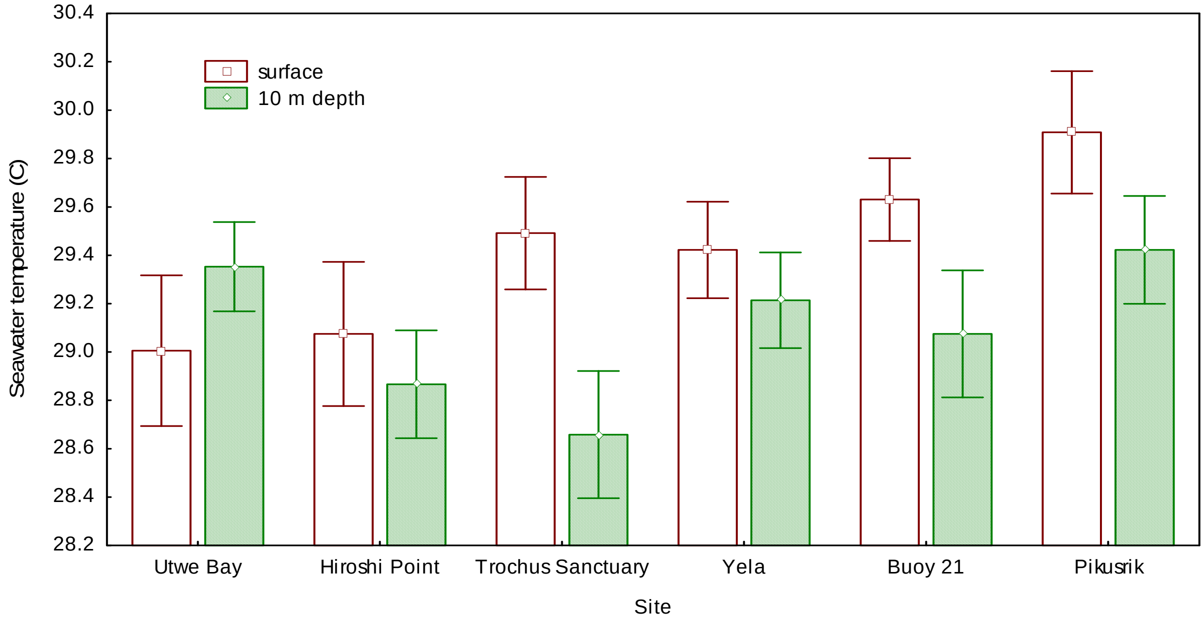

Figure 7. Mean summer (August-September) water temperature at 0 m and 10 m depth at 6 sites in Kosrae, FSM. Data are pooled from 2004 and 2005.

Summer values of salinity also did not differ between 2004 and 2005 at any site (2-way ANOVA, $F = 0.9$, $p = 0.87$). Surface salinity was significantly lower at the mouth of Utwe Bay than at any of the other sites (Figure 8; 2-way ANOVA, $F = 8.1$, $p < 0.05$). Utwe Bay receives more freshwater runoff and riverine input than the other sites.

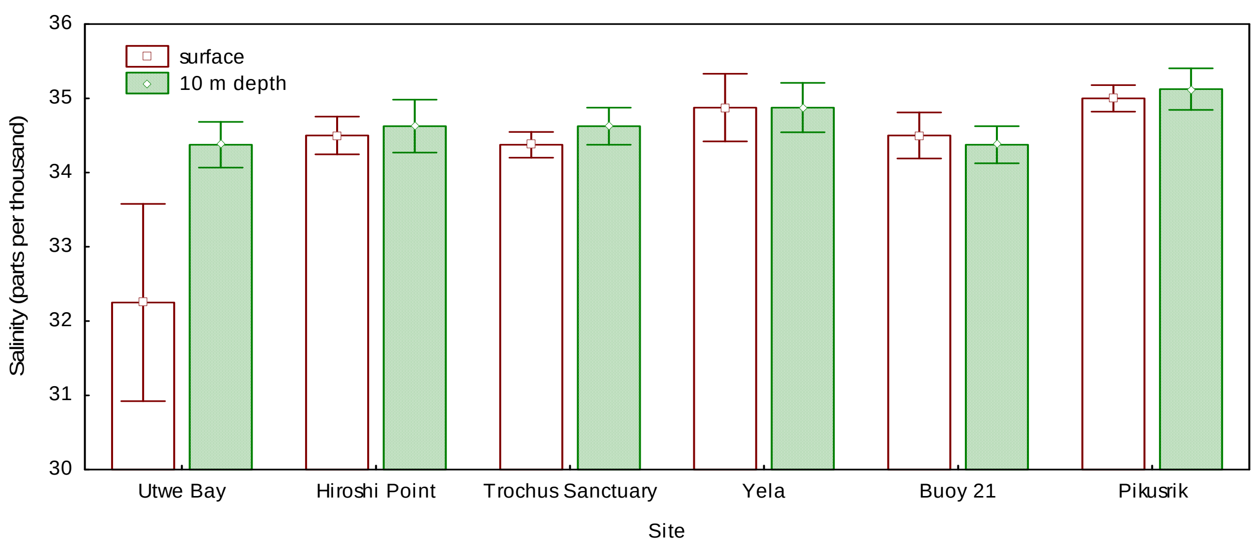

Figure 8. Mean summer (August-September) salinity at 0 m and 10 m depth at 6 sites in Kosrae, FSM. Data are pooled from 2004 and 2005.

Dissolved oxygen (DO) did not vary at all among sites or years (2-way ANOVA, $F = 1.3$, $p = 0.79$). DO at 28-30˚C was generally at or around 6 mg/l (ppm) at all sites and at both depths. This indicates that DO was close to saturation at all sites, since the saturation level for water

28˚C is about 6.5 mg/L. The fact that temperature, salinity and DO did not vary greatly between sites or depths indicates that the seawater over Kosrae's reefs is quite well mixed. Only Utwe Bay tended to have a lens of slighter fresher water at the surface, due to runoff and riverine input.

Water clarity (horizontal visibility) was measured by divers using a Secchi disk attached to a rope marked every meter. There was no significant difference among sites (ANOVA, $F = 5.4$, $p = 0.09$), although there was a non-significant trend toward lower visibility at Utwe Bay (Figure 9). This is again due to increased runoff and riverine input at this site.

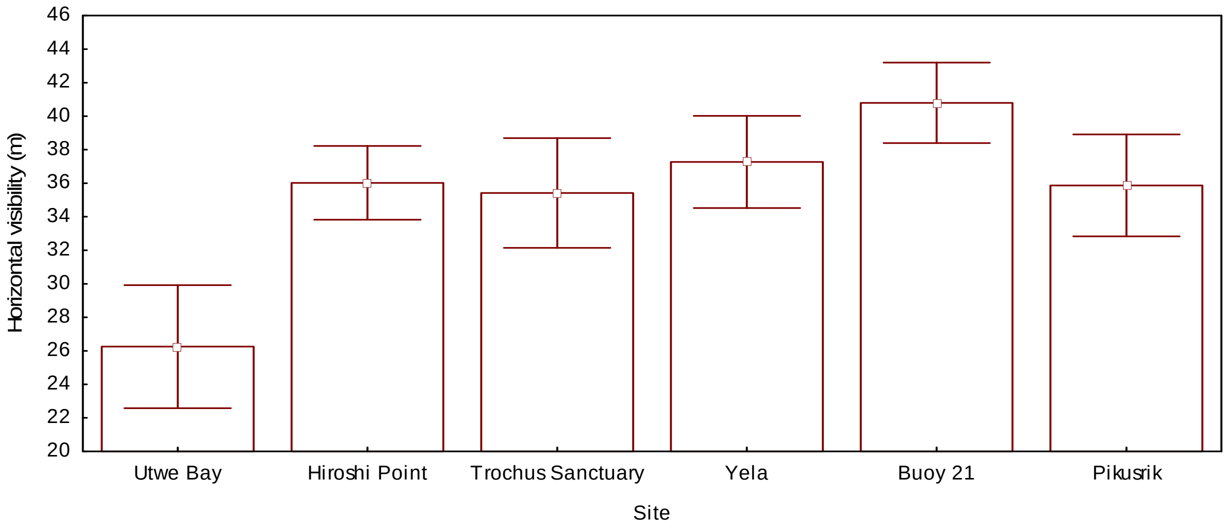

Figure 9. Horizontal visibility (m) at 6 sites in Kosrae, FSM.

Conclusion: Water quality did not differ between sites except for Utwe Bay, which tended to have slightly more freshwater input. Water quality was high at all sites, but may decrease in the Utwe-Walung Marine Park as the road construction there continues.

Testing of Socioeconomic Indicators

The following indicators from the WCPA-Marine/WWF/NOAA list were selected for use in Kosrae. Each was tested according to WCPA-Marine/WWF protocols and Bunce et al. (2000).

1. *Local fisher perceptions of harvest*.

We surveyed 32 fishers (23 female, 9 male) from the villages of Utwe and Malem, near the Utwe-Walung Marine Park. Fishing in Kosrae is traditionally done by women in lagoon and mangrove areas using nets (Rhodes 2003). Fishers were asked to compare their catch per unit effort now with the situation 10 years ago. A self-anchoring scale was used in which 1 indicates that target species are no longer available and 10 indicates that target species are so abundant that there is never any problem catching them. The mean response for 10 years ago was 6.9 ± 1.0. The mean response for the current situation was 4.3 ± 1.5. The responses were significantly different (paired t-test, $t = 8.1$, $p < 0.0001$). Thus, most fishers believed that catch per unit effort has declined by quite a large degree. Some blamed the decline on movement of fish to other reef areas. Only 3 fishers suggested that increases in CPUE were occurring adjacent to the Utwe-Walung Marine Park. Interestingly, our conversations with Kosraean fishers indicated some disagreement as to the level of overfishing occurring. Dive tour operators and many fishers expressed concern that several important species are overfished, while a few believed Kosrae's fish stocks to be relatively pristine. The fish species most often regarded as overfished were humphead wrasse, bumphead parrotfish, and large groupers. This supports our findings (under Focal Species Density above) that these species were very rare, especially compared to other Micronesian islands such as Palau and Pohnpei (Tupper in press).

Conclusion: Local fishers perceive marine resources to be in serious decline in the area around Utwe-Walung Marine Park. It appears that implementation of the Park has done little to reverse this trend.

2. *Community infrastructure*.

Currently, the Utwe-Walung Marine Park and the Trochus Sanctuary occupy relatively uninhabited areas of Kosrae's coastline. Until recently, Walung village could only be reached by boat from Utwe or Tafunsak. A dirt road now connects Utwe and Walung, and plans are in place to pave the road and continue it to Tafunsak, so that the island can be circumnavigated by car. The completion of this road will have major consequences for community infrastructure of Walung village, which currently has no electricity, telephones, or treated drinking water. An increase in development is inevitable, and impacts to the Marine Park and Trochus Sanctuary seem unavoidable. Unfortunately, this indicator was not particularly useful for the Utwe-Walung Marine Park or the Trochus Sanctuary, as the airport and the Utwe-Walung road and associated infrastructure are being paid for with funds from the Compact of Free Association with the United States. The recent increases in infrastructure are therefore unrelated to the creation of the MPAs.

Conclusion: Community infrastructure was not a relevant or useful indicator for MPA management in Kosrae.

3. *Traditional knowledge of natural history*.

The level of traditional ecological knowledge (TEK) on Kosrae is unclear. Kosrae's history involved a higher dependence on small-scale subsistence agriculture (taro, fruit, etc.) than on fishing, although subsistence fishing is widely practiced. Determining the level of Kosraean TEK for coral reef species is especially challenging because of the lack of prominent underwater features with associated biota. Unlike the other Micronesian nations (except Guam), Kosrae is a single island with a narrow fringing reef and no associated atolls, large lagoons, pinnacles or passes. In shallow lagoon and mangrove areas, spawning and movement habits of target species, especially rabbitfishes, are well known and the fish are heavily targeted (Rhodes 2003). Offshore, on deeper reefs, large species such as groupers and snappers are less heavily targeted. For these species, features such as spawning aggregation sites or nursery areas are not readily apparent and are unknown to most Kosraeans.

A survey of 32 Kosraean fishers (23 female, 9 male, as above) and 11 divers (all male) indicated a strong knowledge of local taxonomy. When presented with pictures of key reef organisms, over 90% of respondents agreed on the local names. Local reef fish names perfectly matched those recorded by Rhodes (2003). Kosraeans recognize not only individual species, but distinct life history phases of individual species. Respondents all agreed on local place names (as in village names, reef names, and names of local features such as headlands, bays, coves, river mouths, etc. Local names of spawning sites, particularly rabbitfish, rudderfish and mullet spawning sites, were well-known by the women but less well-known by men. Women also indicated better agreement than men with regard to where inshore (lagoon and mangrove) fish resources were located, and there behaviors and movement patterns. Surveys of spawning aggregation knowledge were already being undertaken in Kosrae in 2002-2003. An excellent summary of this knowledge is available in Rhodes (2003). Feeding behaviors of commonly caught fish were well known as the fishers generally gutted their catch. Locations, behaviors and movements of deeper reef species were generally less well known. Spawning aggregations of groupers were generally thought to occur in deep water (> 100 m) but there was little agreement as to the location and timing of these aggregations. For these resources, men tended to be more knowledgeable than women, or at least had stronger opinions on the matter. There was little agreement between respondents on the locations of large mobile species such as humphead wrasse, bumphead parrotfish and large groupers.

Conclusion: Stakeholder knowledge of natural history was high for the inshore (lagoon and mangrove) species, particularly among women who are the traditional inshore fishers. Stakeholder knowledge of deeper reef species was relatively low.

4. *Local marine resource use patterns*

In order to manage resource use effectively, management agencies must have good data on local use patterns. Currently, none of Kosrae's MPAs have sufficient surveillance to gather useful data on patterns of resource use. This indicator was tested through two surveys of MPA users, one directed at fishers and another at local dive tourism operators. Surveys will focus on where, when, and how the MPAs are used. Pertinent questions included: the number of divers per day using the MPAs and which sites they frequent, gear types used by fishers, location of preferred fishing grounds, and amount of daytime versus nighttime fishing effort.

Surveys of gear types, preferred fishing grounds and seasons, and daytime versus nighttime fishing have already been recently conducted by Rhodes (2003). Nets are the primary method, including gill nets (known locally as 'koa') and seines. Trolling for pelagic species (yellowfin tuna, mahi mahi, wahoo, etc.) is common off the reef edge. Bottom fishing for snappers (Lutjanidae), groupers (Serranidae) and emperors (Lethrinidae) is conducted with hand lines or rod and reel by recreational and subsistence fishers, or with electric "bandit" reels by small-scale commercial fishers. Bottom fishing occurs mainly from May to August in deep (> 100 m) water (Rhodes 2003). Nighttime spear fishing also occurs but is infrequent. Fishers were reluctant to reveal locations of their preferred fishing grounds. Fishing did occur within the Utwe-Walung Marine Park, particularly bottom fishing near the western end of the park, but effort appeared low. Dive tour operators tended to operate on the reefs close to their bases. The largest dive operation, based at a resort south of Lelu (see Figure 1), kept its boats in Utwe and primarily covered the southern shore, including the Utwe-Walung Marine Park, from Hiroshi Point to Walung Village. Two other major operators were based near Lelu and Tafunsack respectively. Their boats primarily covered the northern and western reefs. All companies ran small boats and rarely put more than 6 divers in the water at one time. The impact of divers on Kosrae's reefs appears to be minimal.

Conclusion: Local marine resource use patterns indicate moderate fishing pressure and minimal tourism pressure in and adjacent to Kosrae's MPAs.

Testing the Governance Indicators

1. *Existence of a decision-making and management body*

The Utwe-Walung Marine Park is a community-based project, managed by a Board of Directors that includes the Park Manager, private landowners, and directors and senior technical staff of several resource management agencies. Among these agencies are the Kosrae Island Resource Management Program (KIRMP) and the Marine Resources and Marine Surveillance divisions of the Department of Land, Agriculture, and Fisheries (DALF). The Board is responsible for developing and revising the Marine Park Management Strategy, and plans to use the results of this study to revise and improve the strategy. The stated objectives of the Marine Park are “to maintain and manage an area with ecologically valuable, undisturbed and highly scenic features, to provide a variety of benefits, from the protection of natural habitat to enhancing the tourism and recreational appeal of Kosrae, and to provide opportunities for public education and scientific research”.

In June 2005, UNESCO declared the Utwe-Walung Marine Park to be a Biosphere Reserve through their “Man and the Biosphere” program. It is hoped this will facilitate the management of the area.

The Trochus Sanctuary is managed by state resource management agencies (DALF).

2. *Existence and adoption of a management plan*

To date, no formal management plan has been adopted for the Utwe-Walung Marine Park. Management for the Trochus Sanctuary consists of a simple ban on harvesting of Trochus, enforced by the Marine Surveillance Division of the DALF. The DALF also conducts resource assessments of Trochus in the Sanctuary, and of reef fish around the island, including the Utwe-Walung Marine Park.

3. *Existence and adequacy of enabling legislation*

To date, the state of Kosrae has not enacted any legislation concerning the management of the Utwe-Walung. The Trochus Sanctuary is legislated under state code. Harvesting of Trochus within the sanctuary has been prohibited by the KDALF since 1987. It is unclear what fishing regulations, if any, apply to the Utwe-Walung Marine Park.

Conclusion: The Utwe-Walung Marine Park (Biosphere Reserve) currently lacks any state-level legislation or enforcement. This may soon change as there are efforts underway to create and adopt a state-level management plan for the Utwe-Walung Marine Park. The lack of sufficient management and enforcement is probably the reason that no differences were found in focal species abundance and population structure during the biophysical surveys.

Overall Conclusion: The Utwe-Walung Marine Park is not effectively managed and is therefore not meeting its conservation goals. Creation and adoption of a comprehensive management plan, together with effective enforcement, are needed to attain its stated objectives to maintain and manage an area of high ecological value and to protect the habitats therein.

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